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UNITED STATES ARMY AVIATION BOARD
Fort Rucker, Alabama

ATBG-DT-AVN-3360

12 FEB 1975

SUBJECT: Evaluation of Cargo Loading Mirrors on the HU-1().

TO: Commanding General
United States Continental Army Command
Fort Monroe, Virginia
ATTN: ATDEV

I. AUTHORITY. DF, ATDEV-6 (4 Dec 59), Headquarters, USCOMAR, 1 December 1959, subject: "HU-1B(C) Cargo Loading Mirrors."

II. PURPOSE.

1. To investigate the drag and loss in range due to cargo loading mirrors on the HU-1().
2. To recommend an appropriate mirror installation to the HU-1C Mock-up Board.

III. SCOPE. Pilots of the US Army Aviation Board flew the Board's HU-1A with and without a locally-fabricated cargo loading mirror installation for a period of approximately 10 hours to evaluate the loss in range and power attributable to the drag of the mirror installation. Additionally, various experienced cargo helicopter pilots flew the HU-1A on external load missions to determine the number and optimum size of mirrors required for this type of mission.

IV. GENERAL INFORMATION.

1. Background.

a. General. As a result of helicopter towing, external load-carrying, and cargo hook-up problems, it has been determined that rear-view mirrors installed on cargo-type helicopters are highly desirable for use by the pilot. The Army Aviation Board has investigated numerous configurations and modifications of mirrors for helicopters, none of which has been entirely satisfactory. At the completion of the confirmatory test of the HU-1A, a Request for Alteration was submitted, recommending that mirrors be provided on the HU-1A and subsequent models. It was pointed out that,

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during the service test of the YH-40 (HU-1), mirrors were locally installed to aid in external load hook-ups. Use of these mirrors eliminated the requirement for one ground-crew signalman, permitted the pilot to actually view the hook and hook-up and reduced the time required for hook-up. The data obtained during the service test was confirmed during the confirmatory tests.

b. Mirror Installation Drag. A letter dated 1 December 1959, from USCONARC Ln0, Wright Air Development Division, stated that Bell Aircraft Corporation has indicated that the mirror arrangement proposed for the HU-1B(C) helicopters has a flat plate drag area of 3.71 square feet. Bell concluded that these mirrors, if left in the extended position, will require 64 horsepower at 100 knots airspeed and would result in a range reduction of 7.3 percent at 100 knots airspeed. It was then suggested that provisions for storing the mirrors in the cargo compartment, when not in use, be provided. USCONARC requested this Board to investigate the drag caused by the proposed mirror arrangement.

c. Size and Number of Mirrors Required. At the preliminary HU-1C mock-up the question of a valid requirement for a copilot's mirror and the size required for the pilot's mirror was discussed. It was generally agreed that the copilot did not require a mirror. However, the Aviation Board representatives agreed that the Board would investigate the size and number of mirrors required with a view toward recommending a mirror installation for the HU-1C. The consensus was that the resulting installation would be applicable to both the HU-1A and HU-1B.

2. Description of Materiel. A locally-fabricated "bread-board" type of cargo loading mirror installation was installed on the Board's HU-1A. The installation consisted of two 7- x 15-inch mirrors mounted on a 66- x 3/4-inch tubular lightweight metal rod. This rod was mounted on a perforated bracket which attached to the forward fuselage directly ahead of and below the pilot's and copilot's foot level, thus allowing a direct line of sight from the mirror to the cargo hook. The mirrors were secured and adjusted for tilt with two wing-nut-lock-washer combinations. Each mirror was protected by a removable canvas cover equipped with four snap fasteners. The complete installation weighed seven pounds.

V. TESTS.

1. Physical Characteristics. This mirror installation was flown and evaluated by various Board pilots with results as follows:

a. There was no noticeable vibration of the mirror in flight. This was attributed to the rigidity of the mirror-holding bracket.

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b. Mirrors could easily be adjusted on the ground to suit an individual pilot's particular requirement. However, temporary in-flight adjustments could be made by other pilots by merely adjusting the pilot's or copilot's seat.

c. The snap-fastener covers eliminated reflections from mirrors on night flights.

2. Flight Characteristics.

a. General. The HU-1A with and without the complete mirror installation, and with the mirrors installed and removed from the mounting brackets, was flown through various regimes of flight to investigate the effect of the installation on flight characteristics. One-hundred-nautical-mile radius-of-action missions were flown over a measured course at 500 feet pressure altitude at 100 knots true airspeed (TAS) with a takeoff weight of 6200 pounds. Additional missions were flown at 85 knots TAS. Results were as follows:

(1) There was no noticeable effect on flight characteristics with or without the complete mirror installation at airspeeds from 0 to 105 knots.

(2) For range missions:

Flight Time (Min.)	R.P.M.	Torque Pressure (P.S.I.)	OAT. (C.)	Fuel Flow (P.P.H.)	Fuel Consumption (Gal.)	Fuel Power (%)
- 100 Knots -						
Mirrors Installed	120	6400	26/23.5	19°	500/455	157
Mirrors Removed (Brackets Remaining)	120	6400	26/23.5	19°	500/455	156.5
Complete Mirror Installation Removed	120	6400	26/23.5	19°	500/455	154
						88.5/86.7
						88.5/87
						88/87

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	Flight Time (Min.)	R.P.M.	Torque Pressure (P.S.I.)	OAT. (C.)	Fuel Flow (P.P.H.)	Fuel Consumption (Gal.)	Fuel Con- sumption Power (%)
- 85 knots -							
Mirrors Installed	120	6400	21.5/19	20°	455/420	138	86/84.5
Complete Mirror Installation Removed	120	6400	21.5/19.5	20°	455/420	137	86/84.8

b. Discussion.

(1) The range mission data shows that there is very little increase in drag at the higher airspeed (100 knots) with the mirrors installed. The data indicated a range reduction of two percent and a horsepower requirement of not more than 10 to 15 horsepower. This drag effect is not apparent in an increase in torque pressure or fuel flow; however, it is apparent in difference in fuel consumption. It is estimated that this drag may be reduced approximately 35 percent and the weight reduced three pounds by removing the copilot's mirror. Further, the mirrors themselves produce negligible drag, thereby eliminating a feathering requirement to reduce drag. The high drag item is the mounting brackets which hold the mirror. It is apparent from an examination of the installation that this drag could be reduced by proper aerodynamic design.

(2) In the 80-90 knot speed range, which was reported by AVN 3159 to be the best cruise airspeed, there was no significant drag with the mirrors installed, indicating no requirement for removal or folding of the installation.

3. Optimum Size and Number of Mirrors. Various pilots with copilots flew the test aircraft on typical training missions with emphasis on external cargo hook-ups to determine the size and number of mirrors required. Results were as follows:

a. The optimum-size mirror required for the pilot was approximately 7 x 15 inches. A mirror of lesser dimensions would not be suitable.

b. A flat mirror was most satisfactory. A convex mirror was not as suitable.

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c. A copilot mirror was found to be a desirable item, particularly during external load training. However, it was not required for tactical missions.

VI. CONCLUSIONS.

1. A fixed, rigid, mirror installation which allows ground adjustment of the tilt angle is satisfactory for the HU-1(). A mirror cover is required.

2. Loss of range utilizing both a pilot and copilot mirror with a "bread-board" type of installation is approximately two percent at 100 knots and requires not more than 15 horsepower. This loss could be appreciably reduced by the removal of the copilot mirror and reducing the drag of the holding bracket.

3. The mirrors themselves create negligible drag, thereby eliminating any requirement for feathering or removal of the mirror to reduce drag.

4. At the best cruise airspeed the mirror installation produces negligible drag, thereby eliminating any requirement for folding the holding bracket to reduce drag.

5. A copilot mirror is a desirable item, particularly for external load training, but is not required.

6. The optimum size of pilot's mirror is approximately 7 x 15 inches. A mirror of lesser dimensions would not be suitable.

7. A flat-type mirror is desired.

VII. RECOMMENDATIONS. It is recommended that:

1. A single flat-type mirror, approximately 7 x 15 inches and mounted on an aerodynamically clean, rigid installation which allows tilt of the mirror to be adjusted on the ground, be standardized for use as a cargo loading mirror on HU-1() helicopters. A mirror cover must be provided.

2. No further consideration be given to in-flight adjustment, folding, or removal and storage of cargo loading mirrors on the HU-1() Helicopters.

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VIII. COORDINATION. This report has been coordinated with the United States Army Aviation School.



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